EP 000526383 A1
FEB 1993

93-038660/05 E36 F09 **UNBC 91.08.01**
UNION CAMP PATENT HOLDING INC *EP 526383-A1
91.08.01 91US-739050 *(93.02.03)* D21C 9/153
Pulp bleaching process - involves removing carbon di:oxide from used ozone-rich oxygen-contg. gas recycled to ozone generator (Eng)
C93-017436 R(AT BE CH DE DK ES FR GB GR IT LI LU MC NL PT SE)
Addnl. Data: JOSEPH J C, PIKULIN M A, FRIEND W H
92.06.09 92EP-610043

O_2-contg. gas is rendered O_3-rich in an O_3 generator (14) and used in a reactor (18) to bleach pulp, exhaust gas (22) from the reactor (18) being recycled (32) to the O_3 generator after being purged (24) of contaminants, including CO_2 scrubbed pref. by alkali.
Specifically contaminants removal (24) is controlled to keep the O_2 content of the gas at predetermined level, and CO_2 concn. at 6 wt.% or less.

An appts. for reducing the concn. of N_2 in pulp while increasing the consistency of the pulp is also claimed.

ADVANTAGE

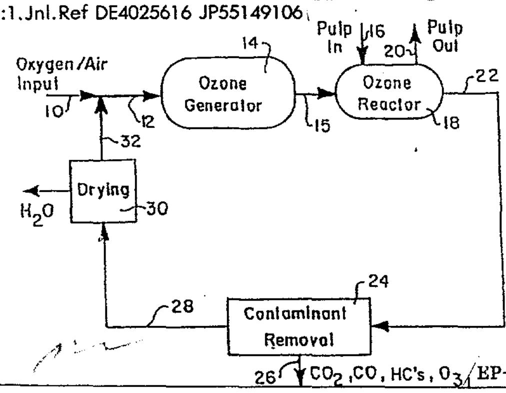
The O_3 generator (14) can operate at or near full capacity (claimed).

E(31-D3, 31-H3, 31-N5C) F(5-A2B)

PREFERRED METHOD

Before O_3 bleaching the pulp is roller-compressed for liq. removal, and exposed in a hood contg. O_2 which enters pulp voids and displaces N_2.(21pp006JWDwgNo1/7).

SR:1.Jnl.Ref DE4025616 JP55149106



EP-526383-A

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 526 383 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **92610043.9**

(51) Int. Cl.[5] : **D21C 9/153**

(22) Date of filing : **09.06.92**

(30) Priority : **01.08.91 US 739050**

(43) Date of publication of application :
03.02.93 Bulletin 93/05

(84) Designated Contracting States :
AT BE CH DE DK ES FR GB GR IT LI LU MC NL PT SE

(71) Applicant : **UNION CAMP PATENT HOLDING, INC.**
919 Washington Street
Wilmington, DE 19801 (US)

(72) Inventor : **Joseph, James C.**
201 Crestview Way
Yardley, PA 19067 (US)
Inventor : **Pikulin, Michael A.**
559 Winsor Street
Bound Brook, NH 08805 (US)
Inventor : **Friend, William H.**
22 Sweetgum Crossing
Savannah, GA 31411 (US)

(74) Representative : **Birkeholm, Mogens**
Larsen & Birkeholm A/S Skagensgade 64 P.O. Box 200
DK-2630 Taastrup (DK)

(54) Process and apparatus for conditioning ozone gas recycle stream in ozone pulp bleaching.

(57) A process for conditioning an ozone gas recycle stream in an ozone pulp bleaching process, wherein the level of carbon dioxide in the recycle stream is controlled to allow full capacity operation of the ozone generator. Carbon dioxide concentration is identified over the relevant operational ranges and maximum concentration is identified for full capacity/optimum efficiency operation. Specific methods are described for controlling carbon dioxide concentration including purging a portion of the recycle stream, counter-current scrubbing of the recycle stream with an alkaline solution and passing the recycle stream through an adsorbent material. Contaminants entering the system also may be reduced by directing the purged recycle stream, which is relatively oxygen rich, into the dewatering press where pulp consistency is increased. In this manner nitrogen surrounding the pulp is displaced by oxygen and thus, does not enter the bleaching/ozone system with the pulp.

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plant and recycle system is actually achieved.

Summary of the Invention

It is therefore an object of the present invention to operate an ozone recycle system in a pulp bleaching process in a manner which utilizes the full generation capacity of the ozone generator. In achieving this object, it has been observed that the actual amount of carbon dioxide produced in a pulp bleaching process is greater than previously predicted. Also, carbon dioxide has much greater effect on the ozone generation efficiency than was previously recognized in the art. Thus, the present invention provides for removal of carbon dioxide and other contaminants in amounts sufficient to prevent build up in the ozone recycle stream of a pulp bleaching process. This provides the advantage of maintaining a higher ozone generation efficiency in a smaller size generator than was previously possible, thereby reducing the overall cost of operating such a system.

The process according to the present invention generally includes the following steps: An oxygen containing feed gas is provided to an ozone generator. Ozone is generated from the oxygen containing gas to produce an ozone rich oxygen gas which preferably has an ozone concentration of about 6 wt%. Pulp is bleached with the ozone rich gas and, as a result, produces an exhaust gas containing contaminants including relatively large amounts of carbon dioxide. Contaminants are removed from the exhaust gas to produce a recycle gas. The recycle gas is directed into the ozone generator to provide at least a portion of the oxygen containing feed gas used to generate the ozone. In order to allow the ozone generator to operate at full capacity, or at least approaching full capacity, a sufficient amount of carbon dioxide is removed from the exhaust gas to produce the recycle gas. The amount removed preferably maintains the carbon dioxide concentration at about 6 wt% or less in the feed gas.

In one preferred embodiment of the present invention, carbon dioxide is removed by purging a portion of the exhaust gas. The unpurged portion becomes the recycle gas that is mixed with a fresh oxygen containing gas. The mixture forms the feed gas and is then directed into the ozone generator.

In an another preferred embodiment of the present invention, carbon dioxide is removed by passing the exhaust gas through a pressure swing adsorbtion unit.

In a further preferred embodiment of the present invention, carbon dioxide is removed by counter-current scrubbing of the exhaust gas with an alkaline material. Alkaline materials may be conveniently obtained from sources associated with pulping and bleaching processes, such as oxidized white liquor.

A further embodiment of the invention utilizes at least a portion of the purged exhaust gas by directing it into the hood of a dewatering press located in the associated pulp processing stream, upstream of the bleaching reactor. The dewatering press is used to increase the consistency of the pulp by squeezing it to force out water. When the pulp expands after squeezing, it normally absorbs the surrounding air which is primarily nitrogen. This nitrogen normally would be introduced into the bleaching reactor with the pulp and form part of the exhaust gas from the reactor. However, by directing at least a portion of the oxygen rich exhaust gas to the dewatering press, the ambient air is displaced and nitrogen does not enter the pulp in large quantities.

The invention further comprises an apparatus for reducing the concentration of nitrogen gas in pulp while increasing the consistency of the pulp. The apparatus comprises means for increasing the consistency of the pulp by removing liquid therefrom and means for forming a blanket of oxygen rich gas which substantially surrounds and contacts the pulp as the consistency thereof is increased. The oxygen rich gas fills voids created within the pulp by the action of the consistency increasing means. The blanket of oxygen rich gas is created by surrounding the pulp consistency increasing means with hood means. The apparatus further comprises means for directing an oxygen rich gas, preferably a portion of the exhaust gas from an associated ozone recycle system, containing at least about 80% oxygen into the hood means.

The pulp consistency increasing means comprises at least two rollers for pressing the pulp. Upon exiting the rollers the pulp expands as noted above, forming voids within the pulp particles which then fill with the oxygen rich gas.

Brief Description of the Drawing

The features and advantages of the invention will be readily apparent from the following detailed description of the preferred embodiments, illustrated in the drawing figures, wherein:

FIG. 1 is a process flow diagram generally illustrating the process according to the present invention;

FIG. 2 is a graph plotting ozone yield (generation efficiency) in lbs/kW-hr versus the carbon dioxide content of the feed gas in weight percent;

FIG. 3 is a schematic diagram illustrating two different preferred embodiments of the present invention which utilize essentially the same components;

pound of ozone consumed in the bleaching process. This results in the production of typically about 3.3 pounds of carbon dioxide for every air dried ton (ADT) of pulp bleached. The applicants have determined that, for optimal bleaching, the ozone concentration in the gas stream entering the pulp bleaching reactor should not fall below approximately 6 wt% at the design flow rate. A suitable bleaching process and reactor is described in U.S. patent application Serial No. 07/604,849, filed October 26, 1990 which is specifically incorporated herein by reference.

To achieve this ozone concentration the carbon dioxide concentration in the feed gas should not exceed 6 wt%. Carbon dioxide concentration may be decreased below 6 wt% without negatively impacting generation efficiency. However, reductions below this level provide decreasing benefits and can actually decrease overall cost efficiency due to the added cost of unnecessarily removing additional carbon dioxide.

The amount of carbon dioxide produced by ozone pulp bleaching is relatively large: In general, it is much larger than the amounts of carbon dioxide generated in other prior art ozone applications. For example, according to the manufacturer the preferred ozone generators described above should be capable of producing 6 wt% concentration ozone at the design flow rate so long as the oxygen purity of the feed gas is maintained at 85 wt% (or more), regardless of the make-up of the remaining 15 wt%. However, if these generators are included in a recycle system as shown in FIG. 1 and operated according to the prior art with the contaminant removal accomplished by purging a portion of the exhaust gas and adding oxygen make-up gas to maintain the overall oxygen purity in the feed gas at 85 wt%, the carbon dioxide level in the feed gas would rise to about 9.3 wt%. This level, shown in Example I, would be considered acceptable according to the prior art. At this level of carbon dioxide concentration, the ozone generators described above would be unable to produce 6 wt% ozone rich gas without a significant reduction in flow rate.

There are a number of known ways to increase the ozone concentration in the gas exiting an ozone generator. The most direct solution in the prior art would have been to increase the power input to the ozone generator. However, because ozone generation efficiency decreases as power density increases, a point of diminishing returns is reached where ozone concentration cannot be further increased by this method. Increased power also involves increased cost. The further solution in the prior art would have been to increase the generator size, thus increasing efficiency by operating at a lower power density. Another prior art solution would be to decrease flow rate through the generator, but while concentration can be increased, the total volume of ozone produced is decreased due to the lower flow rate.

Each of the prior art solutions listed above results in an increase in the cost of ozone production, either due to decreased productivity or increased capital or operating costs. These increased costs arise because the generator is not operating at full capacity. Operation at full capacity occurs when the ozone generator is producing a maximum ozone concentration at a given generator size, power density and flow rate such that the only way to increase the concentration is to change one of those parameters and thereby incur a productivity loss or an increase in operating or capital cost. The practical effect of each of these changes is the same as increasing the size of the generator when the total amount of ozone produced is considered.

The effect of an increase in generator size under these circumstances is to create a wasted or excess generation capacity because the full capacity cannot be utilized due to the previously unrecognized effects of carbon dioxide. By employing the teachings of the present invention, the excess capacity used to compensate for the effects of carbon dioxide may be eliminated. Two possible, beneficial options result:

(1) generator size can be reduced to operate at full capacity, thereby reducing system capital costs; or

(2) generator size can be maintained to allow for future production increases by utilizing generator capacity which, under the prior art, was wasted. The second option is particularly useful for an existing plant which may increase production by employing the present invention, without installing a new ozone generation system.

FIG. 3 illustrates a preferred embodiment of the present invention, wherein the carbon dioxide level is controlled by continuously purging a portion of the exhaust gas. For ease of reference, this embodiment is referred to below as the "purge only" embodiment. In the system shown in FIG. 3, oxygen make-up gas 40 is mixed with dried recycle gas 86 to form a feed gas 42. Feed gas 42 is directed into ozone generator 44 and thereafter, ozone rich oxygen gas 46 passes through ozone reactor 48 where it bleaches pulp 50. Bleached pulp 52 is removed from ozone reactor 48 and exhaust gas 54 is directed to a counter-current scrubber 56.

Counter-current scrubber 56 uses water 58 as a scrubbing material to remove entrained pulp fibers from the exhaust gas in a solution 60. The operation of a counter-current scrubber in this manner will be understood by persons of ordinary skill in the art.

After scrubber 56, the exhaust gas pressure is maintained by compressor 64 and directed through thermal destruct 68 and catalytic destruct 72 for initial contaminant removal. Each of these components are also commercially available and understood by persons skilled in the art. Thermal destruct 68 removes carbon monoxide generated by the bleaching process and residual or unused ozone. Residual ozone exiting the reactor is con-

the pulp. By flooding hood 130 with purge gas 70, the purge gas surrounds the pulp instead of ambient air. Thus, as the pulp particles expand after exiting the rollers of the press, the voids within the pulp are filled with the purge gas, which includes only about 15% diluents. Air which otherwise would surround the pulp includes approximately 79% diluents, primarily nitrogen. After leaving the flooded hood 130, pulp 49 is directed to a suitable reactor feed device, such as screw feeder 134. From feed device 134, pulp 50 is subsequently fed into reactor 48.

By recycling purged exhaust gas 70 to hood 130, the exhaust gas exiting ozone reactor 48 can be considerably higher in oxygen content than it would be without the introduction of the purge gas to the hood of the DWP. Thus, under many circumstances directing the purge gas to the DWP lowers the oxygen make-up requirement in the feed gas going into the ozone generator and thereby creates substantial additional cost savings. While the overall oxygen purity of the feed gas can be maintained in this manner, at the same time the carbon dioxide concentration must be kept at low levels as previously explained. In some circumstances it may not be desirable to utilize the entire purge gas in the DWP (see Example IV) due to the large amount of contaminants, particularly carbon dioxide, which would be reintroduced into the system with the pulp. If such were the case, it may be desirable to direct only a portion of the purge gas to the DWP or none at all. Vent 133 and control valves 135 and 137 allow the amount of purge gas 70 directed to the DWP to be precisely controlled to achieve a desired balance of oxygen purity and carbon dioxide content.

Instead of the purge gas, any oxygen rich gas (i.e., one having an oxygen content of at least 50%, preferably 80% or more) can be used. Benefits are obtained by the substitution of any oxygen bearing gas having an oxygen concentration which is greater than that of ambient air, so long as the selected gas stream does not contain a significant amount of carbon dioxide.

Turning now to FIGS. 6 and 7, there is illustrated an embodiment of an apparatus according to the present invention for use in surrounding the pulp at the dewatering press with a blanket of exhaust gas from the ozone recycle system purge. The dewatering press 132 used with the invention as depicted in FIGS. 6 and 7 is well-known in the art and thus need not be described in detail here. It is sufficient to say that pulp 50 enters vat 136 through at least one pulp inlet 138 and continuously fills vat 136 located therein. The pulp in vat 136 is dewatered by passing between press rollers 140 so as to raise it from a relatively low consistency to a high consistency between about 25 and 50%, preferably between about 40-50% and most preferably about 42%. Press rollers 140 are synchronously counter-rotated by motor means 142. High consistency pulp 49 then exits hood 130 through discharge chute 143 whereupon it is conveyed to reactor feed device described above. Chute 143 is sealed in a manner to prevent contaminants in the pulp from entering the surrounding atmosphere.

Purged exhaust gas 70 enters chute 143 through pipe 144 and is directed counter-current to the flow of pulp 49. Exhaust gas 70 thus entirely fills the space within hood 130, blanketing the pulp as it passes through rollers 140. As noted above, as the particles of pulp 49 expand upon exiting rollers 140, the voids within the pulp are filled with the oxygen-rich exhaust gas and this pulp, with its relatively higher levels of oxygen and lower levels of diluents, is then subsequently fed into ozone reactor 48. Vent pipe 146 provides an exhaust to prevent overpressurization of hood 130 and to permit the elimination of disagreeable vapors. An exhaust fan (not shown) associated with vent pipe 146 removes the vapors from hood 130 and directs them to a bleach plant scrubber (not shown) for removing sulfur odor. Hoods of the type described herein may be fabricated, for example, from glass-fiber reinforced plastic and are available from Sunds Defibrator, AB of Sundsvall, Sweden, among others. The process of the invention may utilize more than one dewatering press if desired, although for purposes of convenience only one such press is indicated in the drawing figures.

EXAMPLES

The present invention will be further understood by reference to the following non-limiting examples. These examples are based on data generated by a computer model of the ozone generation and recycle system according to the present invention. The examples illustrate the principles of contaminant removal according to the present invention, with the ozone generation system according to the preferred embodiment described hereinabove used for illustration purposes only. Thus, reference to "the ozone generator" in the examples below is to that embodiment. The principles illustrated by these examples may be easily extended to other ozone generation systems by persons of ordinary skill in the art by following the teachings of the present invention.

In each of the examples below the make-up gas on which the model was based contained approximately: 99.5 wt% oxygen, 0.25 wt% nitrogen and 0.25 wt% argon. Amounts of make-up gas input are given in scfm at 298°K. Each of the tables show the concentrations of the gas components in weight percent, except methane (*) which is given in parts per million (ppm). Stream location in the tables refers to the points indicated by the corresponding reference numerals in FIGS. 3 and 5. Specifically, the feed gas to the ozone generator is indicated by 42; the exhaust gas by 54; the exhaust gas after initial contaminant removal by 74; and the recycle

dioxide concentration is maintained at the low 6 wt% level. Under these conditions additional savings could be realized by using a less expensive make-up gas that had a lower oxygen content.

EXAMPLE III

Example III illustrates the benefits which can be realized in terms of reduced make-up gas requirements by flooding the hood of the dewatering press ("DWP") as shown in FIG. 5. However, in this example the purge rate is controlled according to the prior art, i.e. the only concern is maintaining oxygen purity at a level of 85 wt%. This level of oxygen purity can be achieved with a purge of only 8.3%. Table C shows the oxygen and contaminants in the system operated under these conditions:

TABLE C

Stream Location	O_2	CO_2	N_2	O_3	CO	CH_4*	Ar	H_2O
54 Exhaust	79.6	14.1	0.3	0.3	0.6	93.1	0.3	5.0
74 Exhaust	79.5	15.0	0.3	0.0	0.0	.9	0.3	5.0
78 Recycle	80.3	15.1	0.3	0.0	0.0	.9	0.3	4.1
42 Feed	85.0	14.4	0.3	0.0	0.0	.9	0.3	0.0

Purge Rate: 8.3% with DWP flooded
Make-up Gas Input: 174.7 scfm

The amount of make-up gas required is substantially reduced; 174.7 scfm as compared to 251.2 scfm in Example I, which was also controlled according to the prior art to maintain an oxygen purity of 85%. For applications requiring ozone generation at relatively low weight percentages (i.e., about 1-3%), there is a savings in amount of make-up gas. However, the above preferred ozone generator is unable to generate 6 wt% ozone at the design flow rate because, by focusing on oxygen purity only, the carbon dioxide concentration in the feed gas rises to about 14.4 wt%.

EXAMPLE IV

Example IV illustrates the operation of the purge only embodiment, controlled according to the present invention, with the hood of the dewatering press flooded with purge gas as shown in FIG. 5. Table D shows the oxygen and contaminant levels in the system:

TABLE D

Stream Location	O_2	CO_2	N_2	O_3	CO	CH_4*	Ar	H_2O
54 Exhaust	87.3	6.6	0.2	0.3	0.3	90.9	0.2	5.1
74 Exhaust	87.4	7.0	0.2	0.0	0.0	.9	0.2	5.1
78 Recycle	88.2	7.1	0.2	0.0	0.0	.9	0.2	4.2
42 Feed	93.5	6.0	0.3	0.0	0.0	.8	0.2	0.0

Purge Rate: 19.2% with DWP flooded
Make-up Gas Input: 402.8 scfm

In the purge only embodiment, carbon dioxide concentration in the exhaust gas reaches equilibrium at about 7 wt%. This relatively high carbon dioxide content is also present in the purge gas. When the purge gas is reintroduced into the system with the pulp by flooding the DWP, a relatively large amount of carbon dioxide enters the recycle stream. Therefore, although nitrogen can be almost eliminated from the system by flooding the DWP, a slightly higher purge rate of 19.2% (compared to 18.5% in Example II) is required to compensate for carbon dioxide reintroduced with the pulp. By utilizing this higher purge rate, the carbon dioxide level is maintained at 6 wt% in the feed gas, so that the ozone generator can be operated at full capacity.

shows the oxygen and contaminant levels in the system:

TABLE G

Stream Location	O_2	CO_2	N_2	O_3	CO	CH_4*	Ar	H_2O
54 Exhaust	91.4	0.2	2.7	0.3	0.1	90.0	0.2	5.2
74 Exhaust	91.6	0.3	2.7	0.0	0.0	.9	0.2	5.2
78 Recycle	92.5	0.3	2.7	0.0	0.0	.9	0.2	4.3
42 Feed	97.4	0.2	2.1	0.0	0.0	.7	0.3	0.0

Purge Rate: 27.8%; 90% alkaline scrub
Make-up Gas Input: 604.8 scfm

The advantages of flooding the hood of the dewatering press are clear from a comparison of Examples VI and VII.

The detailed description of the preferred embodiments contained herein is intended in no way to limit the scope of the invention. Based on the above examples and teachings of the effects of carbon dioxide provided herein, persons skilled in the art will be able to select the appropriate combination of contaminant removal parameters and make-up gas additions to provide both improved operating efficiency and increased cost savings for operation of a particular ozone generation system. The preferred embodiments described above are not mutually exclusive of one another. For example, the PSA unit according to the present invention may be utilized to remove contaminants from the purged recycle gas of the purge embodiment. The PSA cleaned purge gas then may be directed to the ozone generator or to the hood of the dewatering press. As will be apparent to a person of ordinary skill in the art, various other modifications and adaptions of the structure above described are possible without departure from the spirit and scope of the invention; the scope of which is defined in the appended claims.

Claims

1. A method for conditioning an ozone gas recycle stream in an ozone pulp bleaching process, comprising:
   providing an oxygen containing feed gas to an ozone generator;
   generating ozone from said feed gas to produce an ozone rich oxygen gas;
   bleaching pulp with said ozone rich gas, thereby producing an exhaust gas containing contaminants including carbon dioxide;
   removing at least some of said contaminants to produce a recycle gas;
   directing said recycle gas into the ozone generator to provide at least a portion of said oxygen containing feed gas; and
   removing carbon dioxide during said contaminant removal step in an amount sufficient to allow operation of the ozone generator at or approaching full capacity.

2. The method according to claim 1, further comprising controlling said contaminant removal to maintain the oxygen content of the oxygen containing feed gas at a predetermined level.

3. The method according to claim 1, wherein the amount of carbon dioxide removed from the exhaust gas maintains a carbon dioxide concentration of about 6 wt% or less in the feed gas.

4. The method according to claim 1, wherein said pulp bleaching step produces between about 0.1 to 0.5 pounds of carbon dioxide per pound of ozone consumed during the bleaching step.

5. The method according to claim 1, wherein the amount of carbon dioxide removed is not greater than necessary to allow the ozone generator to operate at or near full capacity.

6. The method according to claim 1, wherein said step of removing contaminants includes purging a portion of the exhaust gas; forming the recycle gas from the unpurged portion of said exhaust gas; mixing said recycle gas with fresh oxygen containing gas to form the feed gas; and maintaining the concentration of carbon dioxide in the feed gas at a level which is sufficiently low to allow approximately full capacity op-

ficient to maintain a carbon dioxide concentration of approximately 6 wt% or less in said feed gas.

20. The method according to claim 19, further comprising controlling overall contaminant removal to provide an oxygen concentration of about 85 wt% or greater in the feed gas.

21. A method for reducing contaminants in pulp prior to the ozone bleaching of the pulp, said method comprising:

pressing pulp in a pulp consistency increasing stage to provide increased consistency pulp by removing liquid therefrom;

expanding the pulp during the pulp consistency increasing stage while creating voids in said pulp;

forming a surrounding blanket of an oxygen rich gas, containing at least about 50% oxygen, around said increased consistency pulp so that said gas contacts substantially all pulp after pressing;

filling voids in said increased consistency pulp with said gas; and

supplying said increased consistency pulp to an ozone-pulp reaction zone for reaction with a gaseous mixture of ozone and oxygen, wherein the amount of contaminants in said increased consistency pulp is reduced by the presence of the oxygen rich gas in the void of the pulp.

22. The method according to claim 21 wherein the oxygen content of the oxygen rich gas is at least 80 wt%.

23. The method according to claim 21 further comprising:

contacting said increased consistency pulp with said gaseous mixture in said ozone-pulp reaction zone to bleach said pulp by removing a substantial portion of the lignin therefrom by reaction with said ozone, while consuming a substantial portion of said ozone by reaction with said pulp, thus producing a bleached pulp and an oxygen-rich exhaust gas; and

directing at least a portion of the oxygen-rich exhaust gas to the consistency increasing stage to form the oxygen-rich gas for surrounding the pulp.

24. A method for reducing contaminants in pulp prior to the ozone bleaching of the pulp, said method comprising:

pressing pulp in a pulp consistency increasing stage to provide increased consistency pulp by removing liquid therefrom;

supplying said increased consistency pulp and a gaseous mixture of ozone and oxygen to an ozone-pulp reaction zone;

contacting said increased consistency pulp with said gaseous mixture in said ozone-pulp reaction zone to bleach said pulp by removing a substantial portion of the lignin therefrom by reaction with said ozone, while consuming a substantial portion of said ozone by reaction with said pulp, thus producing a bleached pulp and an oxygen-rich exhaust gas; and

purging a portion of said oxygen-rich exhaust gas in an amount of up to about 20% by volume, directing said purged exhaust gas portion to said pulp consistency increasing stage, and forming a surrounding blanket of said purged exhaust gas portion about said increased consistency pulp so that said purged exhaust gas portion contacts substantially all pulp after pressing to fill voids in said increased consistency pulp with said first gas portion.

25. An apparatus for reducing the concentration of nitrogen gas in pulp while increasing the consistency of the pulp, comprising:

means for increasing the consistency of a pulp by removing liquid therefrom; and

means for providing a blanket of an oxygen-rich gas to substantially surround and contact said pulp as the consistency of the pulp is increased, so that the oxygen-rich gas fills voids within the pulp.

26. The apparatus of claim 25 wherein the oxygen-rich gas providing means comprises hood means for enclosing said pulp consistency increasing means, and means for directing an oxygen-rich gas containing at least about 80% oxygen into said hood means.

27. The apparatus of claim 25 wherein said pulp consistency increasing means comprises:

press means including at least two rollers for pressing said pulp, wherein particles of said pulp expand upon exiting said rollers such that voids within said particles are substantially filled with said oxygen-rich gas.

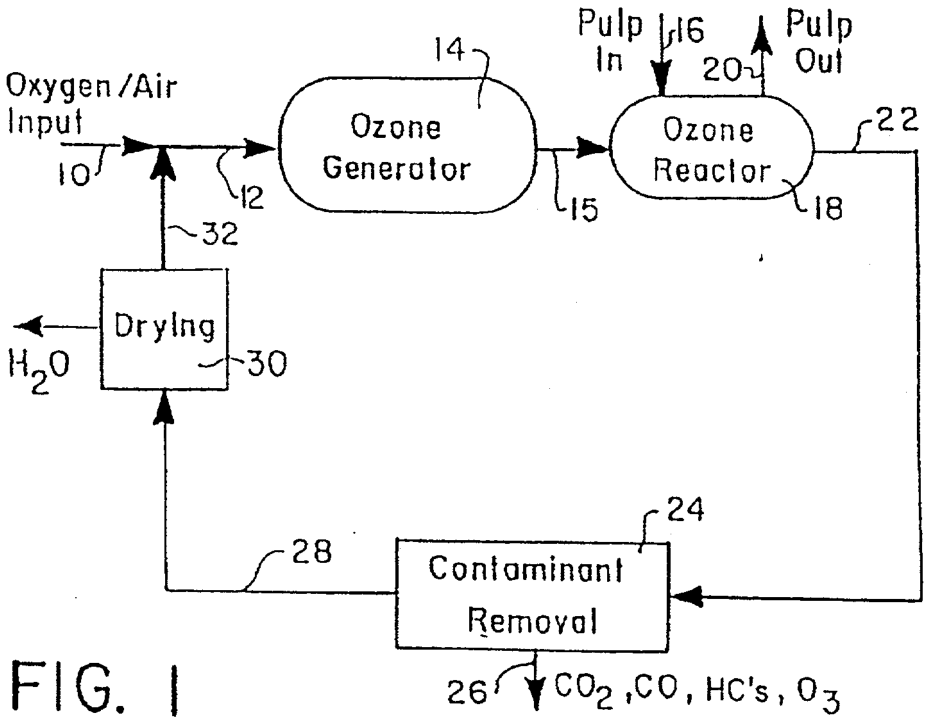
Pulp In
16
Pulp Out
20
14
Oxygen/Air Input
Ozone Generator
Ozone Reactor
22
10
12
15
18
32
Drying
H_2O
30
24
28
Contaminant Removal
26
CO_2, CO, HC's, O_3

FIG. 1

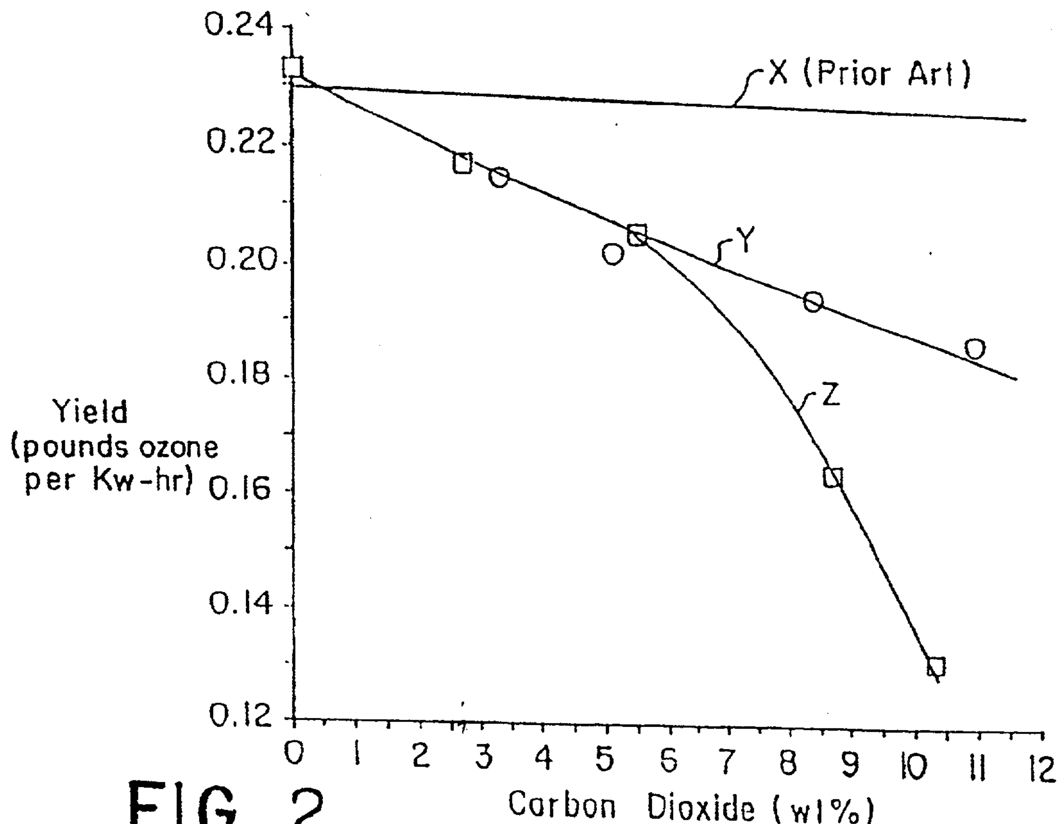
0.24
0.22
0.20
0.18
0.16
0.14
0.12
X (Prior Art)
Y
Z
Yield (pounds ozone per Kw-hr)
0 1 2 3 4 5 6 7 8 9 10 11 12
Carbon Dioxide (wt%)

FIG. 2

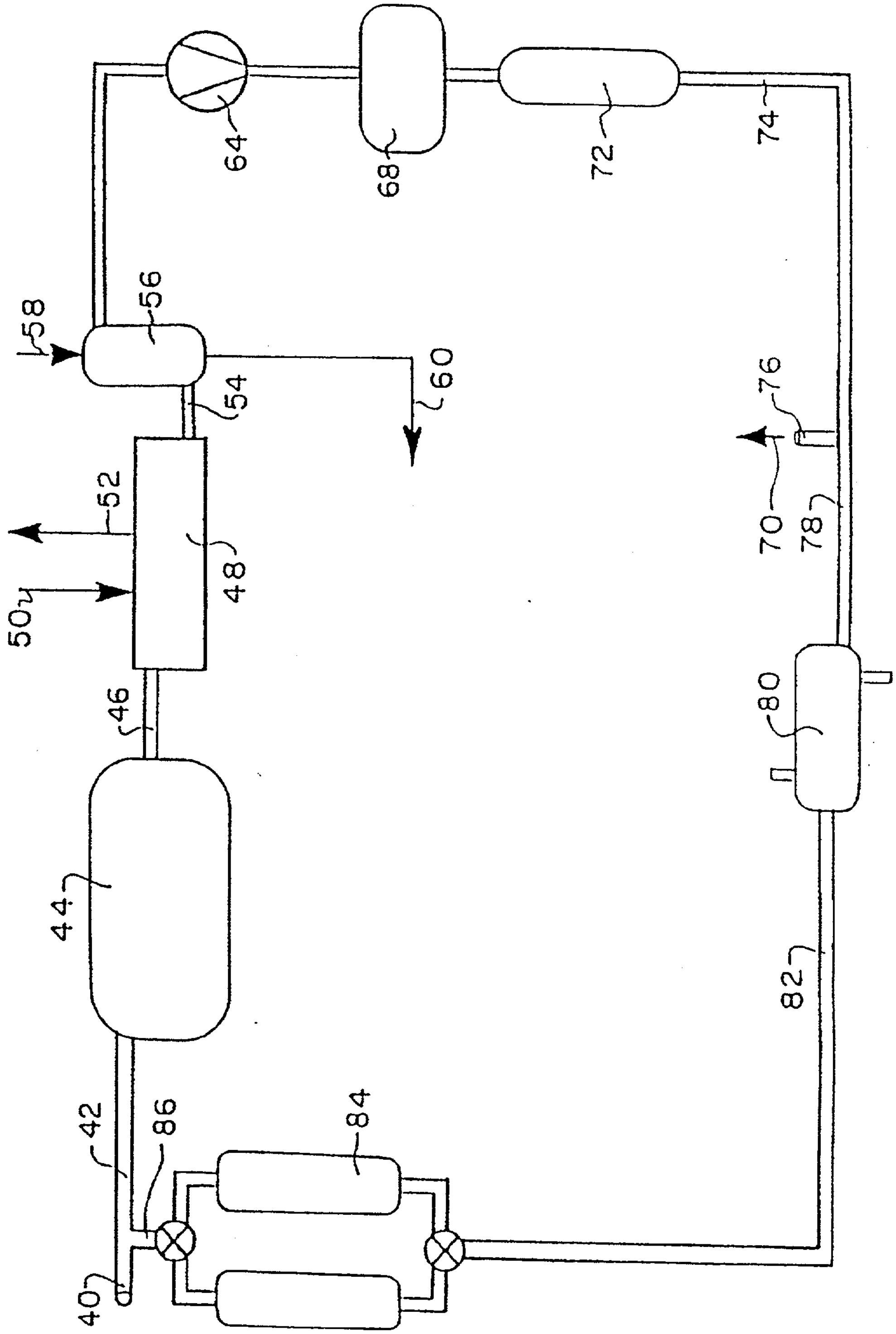

FIG. 3

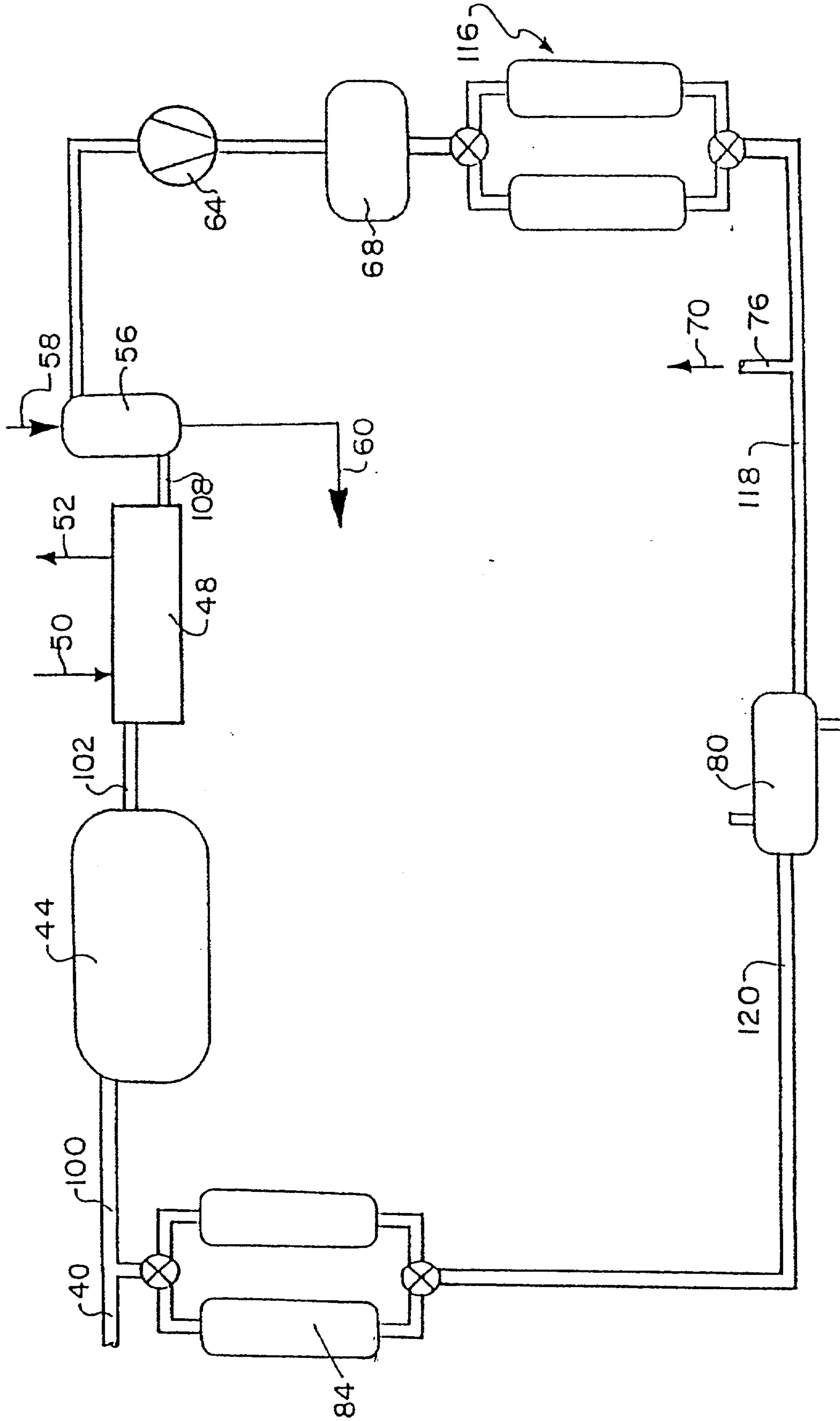

FIG. 4

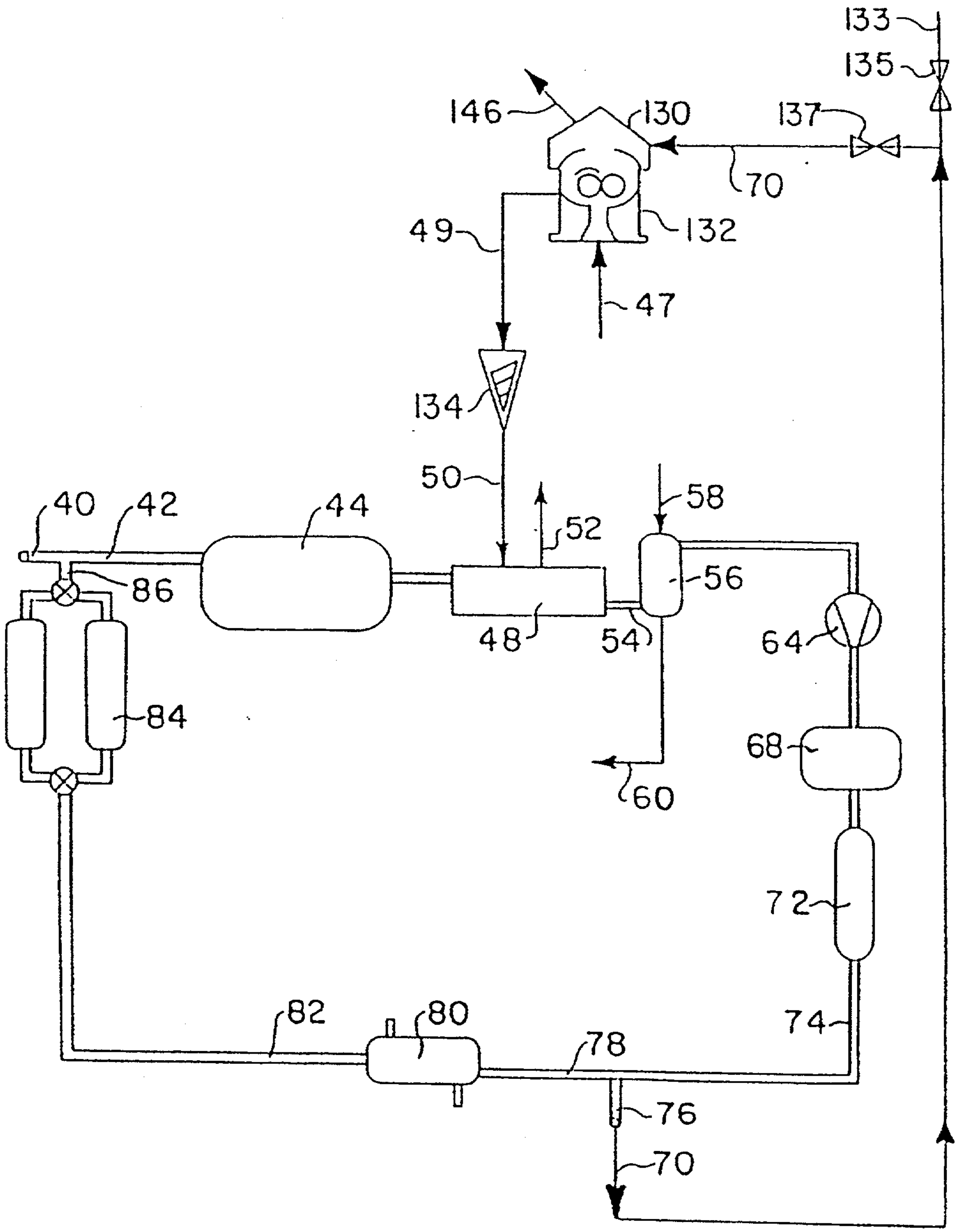
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FIG. 5

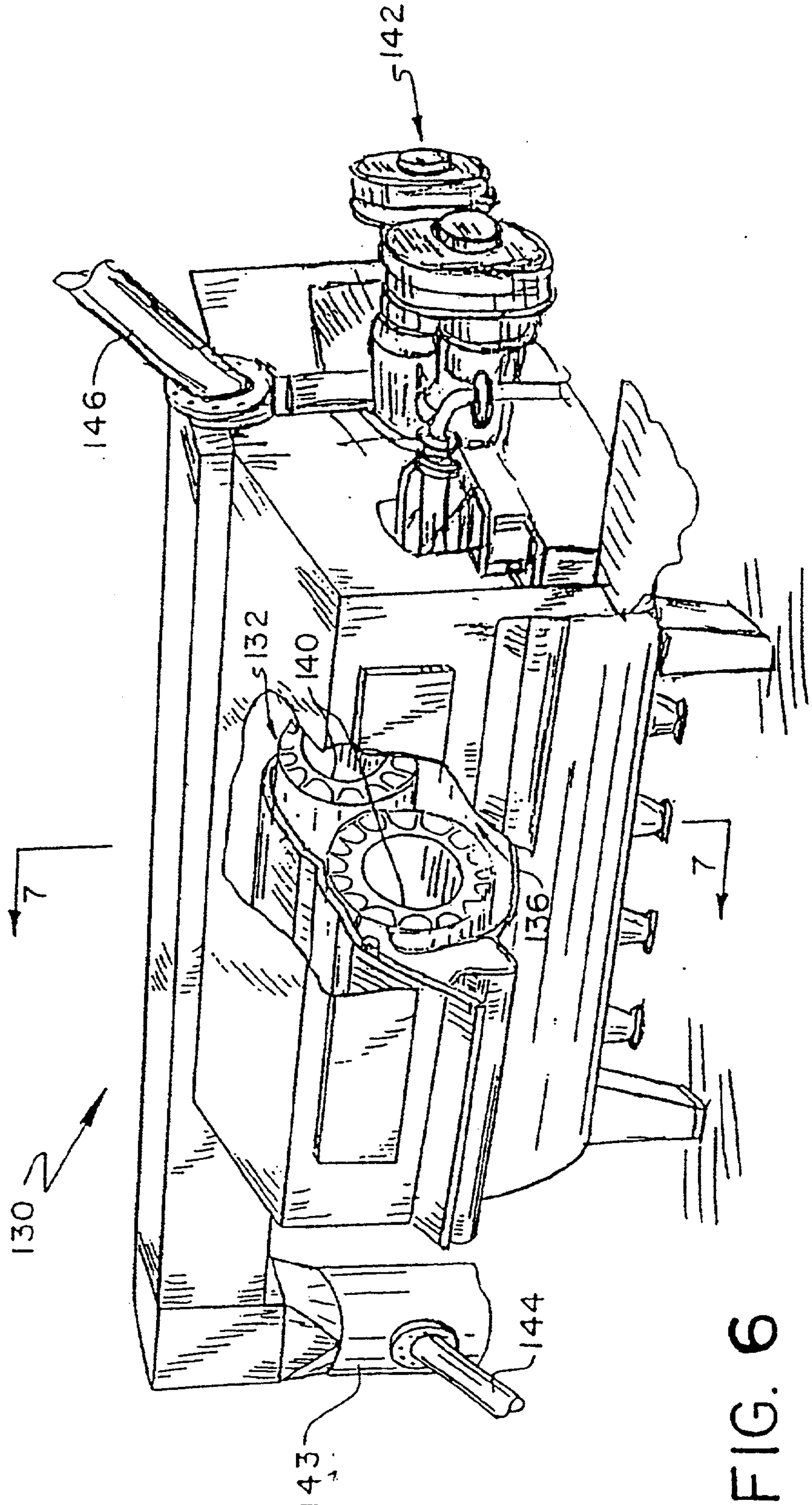

FIG. 6

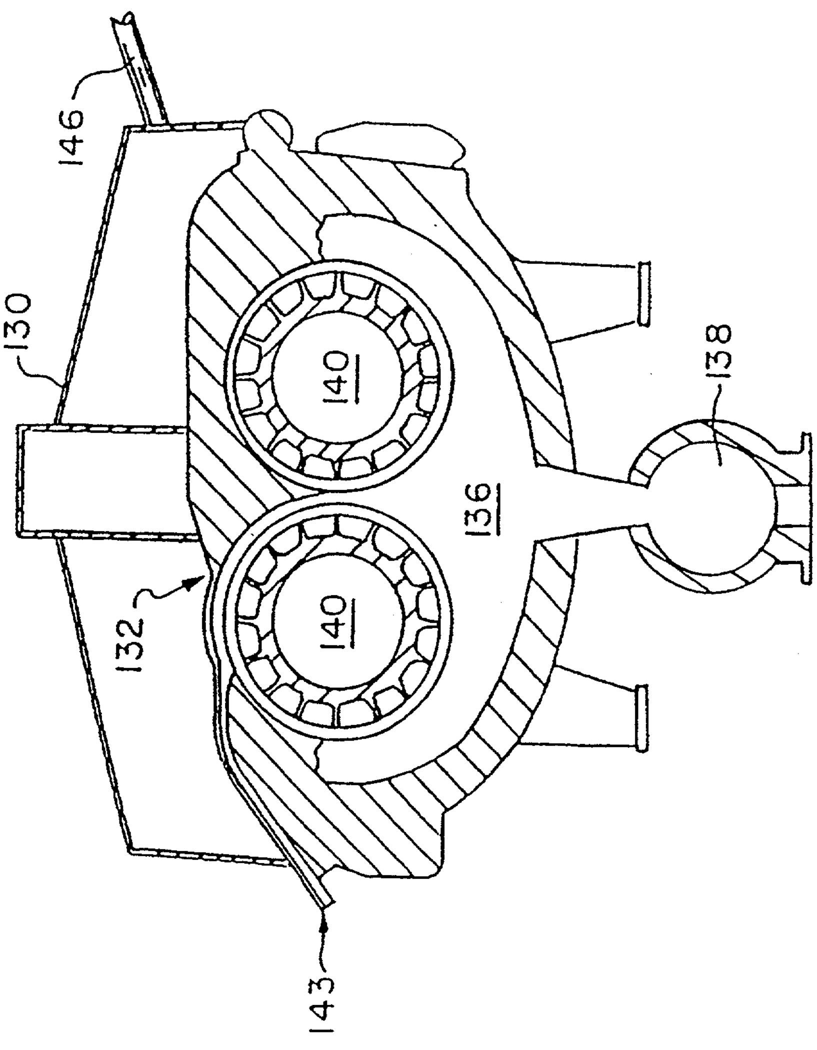

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 61 0043

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
X	PATENT ABSTRACTS OF JAPAN vol. 005, no. 024 (C-043)13 February 1981 & JP-A-55 149 106 (MITSUBISHI ELECTRIC CORP.) 20 November 1980 * abstract *	1,5,15,16	D21C9/153
A		19	
A	DE-A-4 025 616 (MASCHINENFABRIK ANDRITZ AG.) * column 3, line 59 - column 4, line 22 *	21,23,24	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

D21C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	19 NOVEMBER 1992	BERNARDO NORIEGA F.

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